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The History of Art History in the 21st Century, as Viewed from Computer Science: 20-20 Hindsight from the Year of the Same Name

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1. INTRODUCTION

With the passing of a fourth decade since the introduction of computers, those of us who participated in this whole history begin to see some of our earliest predictions being realized. Histories of this period, however, often contain inaccuracies, presumably based on erroneous recollections by the participants.

Accordingly, it occurred to me that I might write such a history, but not one that could be done as well by my contemporaries. Rather, I chose a topic for which I have no contemporaries since most significant progress will be achieved in the next several decades by new, younger researchers. My history of a period ending about the year 2020 will contain some inevitable errors, but probably not many more than do less ambitious histories.

The topic that I shall review is the history of Art History Studies as they have been influenced by Computer Science and Technology. I presume to treat this subject because it appears that we are currently in the same state with respect to this subject as we were four decades ago when many of the principles that later were invoked for great practical benefit in information technology were already known, and others were the topic of informed speculation. So let us now recall the history as viewed from the year 2020.

2. THE VIEW FROM 2020

Computing machines, as we understand them in the contemporary sense, have been with us for three quarters of a century. For about half that time they have been used in art historical studies. The science that underlies these machines have been with us somewhat longer.[1] This survey attempts to recall the way in which Computer Science and also computing machines have contributed to art history in the period from the 1980s to the present. As recollections, the survey can be faulted for inevitably reflecting the biases and limited memory of the observer. It remains for a more scholarly study to document the events, dates, and people associated with the recollections cited here.

In 1954 a small group of scientists and engineers (there being no Computer Science as such at that time) convened to study how computers might be used to create an artificial intelligence.[2] Although they were aware of sizeable literatures in Cognitive Science, Logic, and Linguistics, they ignored the vast literature that documents the creative output of the human mind in artistic creation since Paleolithic times.

Though musical research preceded art research by about a decade, for both the first major accomplishments consisted of the development of software and hardware to enable new creative work to be done. Only later was it discovered that the world's archives contained information of greater value to society than the creative output of contemporary individuals. This insight was encouraged by studies in the late 1980s that quantified the cost to society of maintaining archives of the copious creative output of people assisted by powerful personal computers. It was discovered that a profound asymmetry existed between our ability to create and our ability to understand the products of our creativity. This was first clearly understood in the software crisis of 1995 when it was convincingly demonstrated that software created for the operation of the transportation and communication needs of the Republic of Nirvana could never be made to function reliably despite the best efforts of the United States and the Soviet Union. The software had been in operation for several years with no apparent lacunae when it suddenly ceased its proper function. Various explanations ranging from computer viruses to thermodynamic uncertainty were offered, none satisfactory, until the same phenomenon began appearing worldwide. Major national efforts led to the conclusion that we had overreached our ability to understand the technological objects of our creation. The support given to this view by much earlier studies in logic finally convinced the scientific public that unbridled creativity was not without cost to society.[3] That realization led, at the turn of the century, to the great renaissance in historical studies. The fine arts was a major beneficiary.

3. SCOPE OF THIS SURVEY

We are concerned, in this survey, with what used to be called two- and three-dimensional art. When computers were first used extensively for scanning paintings and sculptures in the early 1990s, it was thought that two dimensions were adequate for representing paintings and three dimensions for sculpture. When MIT won its famous debate with Harvard, in 1992, there was widespread adoption of the ANSI standard for storing art objects. Within a few years so many archives were replaced with digitized counterparts that a special committee of the Computer Art Society was asked to estimate the cost of continuing the practice of digitization to encompass all of Western art. The surprising recommendation was that the practice of digitization should be discontinued. The main support for the recommendation was that irretrievable losses had already taken place in those archives of original art works which had been destroyed in favor of their two- and three-dimensional digital representations which were much more economical to archive. Painting scholars regretted deficiencies in color, texture, transparency and detail in the two dimensional scans. Scholars studying sculpture found all these and tactile and dielectric properties lost in the three-dimensional scans. Accordingly a major effort was made to study the necessary dimensionality of representation for painting and sculpture. There was some dispute over the adequacy of 12 dimensions for paintings, but the consensus was that between 9 and 14 dimensions would be adequate. For sculpture, few people disputed the suggested 16 dimensions.

It was fortunate that in the late 1980s and early 1990s a major military effort had been launched in multi-sensor fusion.[4] The military had realized that unisensory detection devices could not, in principle, rival the performance of human detectors for military targets. The resulting proliferation in both the development of new sensors and new ways of organizing the information they provided was widely known to the military when the Computer Art Society committee discovered multisensor fusion in 1996. So today we no longer speak of pixels in representing paintings, but rather 12 dimensional arrays of vectors. Even the notion of museum walls has been superseded by the more general idea of lower-dimensional projections. The current popularity of 4- and 5-dimensional interactive exhibitions has entirely supplanted the archaic museum exhibition. In Boston alone this year there have been several "projection" shows of the same paintings with different choices of 4 or 5 dimensions from the 12 stored in the Fogg data base. A number of dissertations in the art history department have addressed the choice of appropriate dimensions. One even proposed the adequacy of only dimensions numbers 6, 8, 11, and 12 (specularity, 10 micrometer granularity, and two bands in the visible spectral green and red regions).

Thus we are surveying, in this paper, 12 and 16 dimensional art as it has been influenced by computer science. But we are also concerned with the state of archives, both digital and (largely restored) conventional painting and sculpture.

Another area of concern in this survey is technology based art. Whereas research and exhibition of art have benefited from the insights drawn from computer science and technology, there was also a short period when computers were actually used as an art medium. Images were created on color displays and paper copy by using various manual input devices to control the image generation systems. These systems were called "paint systems." They lasted until 1995 when this technology based art was discontinued in the reaction to the Nirvana creativity crisis. This was, perhaps coincidentally, the same time when many rediscoveries of traditional art took place and a proliferation of studies were directed at new ways of understanding traditional forms by drawing on insights from computer science.

We are also surveying, here, the history of collections and archiving. Since well before computer science and technology were introduced into the fine arts, there was recognition of problems in managing collections of art works. For a period in the 1980s, it was thought that computers would offer palliatives if not cures for some of these problems. But by the end of the 1980s it was understood that in the major area of collection management of historical images from earth satellites, it was no longer possible to avoid widespread loss of unrecoverable imagery. A similar realization occurred later in the fine arts.

The last topic of interest to us in this survey is the history of the contribution from computer science to the interpretation of art works. By the time of the earliest uses of computers, the vast archive of literature on the interpretation of art works was exclusively in textual form. Although some of it had been put into machine readable form, none of it was, in fact, understandable to computers because there was no computational interpretation. The customary art criticism literature, which was all written in natural language, was not capable of being executed on computers. This led to many disputes about not only the nature of the art being criticzed, but the very meaning of the criticism. By 1986, when the first studies of stylistic analysis with algorithms were made, it became clear that, at least for formal stylistic analysis, algorithmic methods could be used as pubication media.[5] Later, automatic discovery methods for criticism algorithms were discovered. Finally, in 2005 the methods of formal algorithmic analysis were combined with developments in semantic modeling to furnish the critical analysis methods we know today.

4. THE PREPARATORY TECHNOLOGY

By the 1980s when serious Computational Art History studies began, a preparatory technology had already been in place for a protracted time. Image processing technology and the science of pattern recognition had already been investigated for three decades.[6] Computer graphics technology had come into widespread use over a period of two decades with as many as 30,000 people attending each of the two annual conferences on the subject.[7] Personal computers had been available for about a decade, thereby making the technologies of image processing and computer graphics widely available, in some cases for as little as ¥100 (in current international currency units).

It took another decade for the two related technologies of digital telecommunication and image storage compression to reach maturity when ATT released its Artline™ fiber optic image storage and communication network in 1998. At the dedication ceremonies for Artline™ a group of art history students caused major disruption with hand-held coherent light sources in their protest over ATT's insistence on the use of only five dimensions of storage for art works (three spatial, one chrominance, and one temporal). Their slogan "ECA: Everything Counts in Art!" survived for almost a decade by which time there remained only a few scholars still insisting on the need for more dimensions for representation in digital archives.[8] But the protests of these scholars was seen as more appropriately directed toward the evolving standards for CogniNet™ which were not finally adopted until 2007.

The main contribution to meeting the students' demand, during that decade, came from the technology of multisensor fusion. To the great credit of the Stanford Center for Art Competitiveness, it recognized the applicability of multisensor fusion to the ECA problem. By demonstrating how the use of ten extra sensors developed under U.S. Army sponsorship could create a representation of the works of Robert Rauschenberg that satisfied the most skeptical critics, Stanford effectively ended the ECA protests.

5. EARLY RESULTS

Art historians and other scholars shared early awareness of computers with studio artists who began using computers with display technology for the production of new art works. It was very easy to maintain tight control of the medium and to use it as an extender of the artist's repertoire. This made possible such impressive accomplishments as animation, experimentation with color, collaborative work, and wide distribution of reproductions. But oddly, it was the very fascination with the new medium that prevented the studio artists from recognizing the real power of the tools that they were using.[9] What the studio artists learned later in the 1990s from art historians was the possibility of using these same tools for looking, in an informed manner, at art works.

During that time, the emphasis in studio work with computers shifted from strict production of new works to production of so called self-explanatory works. Presented in the form of algorithms, a work of art could be run on a computer either by the artist or by an interested viewer. An art work would be produced, but along with it was the derivational history of the execution of the algorithm which came to be called a self-explanation. This led to the popularity of interactive archives in public education because of the readily observable affective response evoked from the participants. It was not clear, however, whether this affective response was to the content of the art itself or to the interactive technology.

There was even a transient movement reminiscent of the Conceptual Art movement to produce self-explanations for distribution unaccompanied by the corresponding art work. Immediately there arose the practice of decompilation (a kind of computer reverse engineering which works backward from a product to its design) which made possible the recovery of the algorithms from self-explanations. Then the recovered algorithms were executed to produce the missing art works. Thus the vacuity of self-explanation with no visual accompaniment was recognized, ending the practice.

The technology of image enhancement which had been available since the early days of space exploration[10] created great excitement in the art history community in 1995 when images (captured in the old three dimensional form) were enhanced to allow new insights into painting. Conservation people had been aware, for a long time, of the use of infrared reflectography and x-radiography for exposing painting underlayments. But they were as enthuasiastic as everyone else when Getty's Digital Laboratory Number 5 was able to reconstruct the whole compositional history of Jackson Pollock's *Lavendar Mist* by careful inspection of the paint strokes by the computer. The animated film that Getty produced in its Wyoming laboratory reconstructed each movement Pollock made in producing the composition. National excitement was so great that for a period of two years, the number of visitors to the Pollock Birthplace Memorial, in Cody, Wyoming, exceeded the number at Yellowstone park. There was even an attempt by the governor of Wyoming to change the name of the New York School.

6. THE ACTIVE 90s

It is clear that the 90s were very active years in the use of computer technology in the fine arts. But there was also rapid advancement in the underlying science and resulting rapid change in social attitudes to art. Major scientific advances took place in computational theories of human vision. Again, the military played a major role. Heavy support for research in visually guided vehicles led to the realization that no such system could be built without drawing heavily from theories in neurophysiology,[11] perceptual psychology,[12] and art history.[13] Of course, the military was more resistant to supporting the latter two of these areas than it was to supporting neurophysiology. But Gibson's insight that human vision can only solve problems drawn from its own ecological niche, supported by Gombrich's that vision has a describable history, eventually convinced the military to support all three areas equally. The decision was vindicated by the award of the Nobel prize of 1999 to Smith, Jones, and Kraunzkopoulous for their model of human vision. This was not only the first such prize for a computer program, but the first given to an art historian. The art history departments at the Universities of Oklahoma and Kansas and the Berenson Computer Annex of the Villa I Tatti in Florence collaborated in this work. At his speech in Stockholm, Kraunzkopolous paid recognition to the beauty of the computer environment in Florence as an important contribution to the research.

Optical discs with image data bases became widely available in the 90s, with vast social ramifications. For as little as ¥100, one could purchase the entire collection of the National Gallery of Art in HDTV format on optical disks.[14] Updates to the collection were ¥10 per year. Museum directors everywhere worried about the effect of this medium on museum attendance. Apprehension was vindicated when a Congressional mandate forced the National Gallery to devote the whole West Wing of the Gallery to the new facility for handling public on-line data base interrogation. The great surprise, however, was the subsequent demand by the public for greater access to original works of art. As a result, the new South Wing of the Gallery was constructed in record time despite political objection that it blocked the view of the Capitol from the Washington Monument grounds.[15]

Social historians credit this conflict between those who demanded greater access to on-line image data bases and those demanding more access to original works with providing the motivation for the New Luddites. This group objected to the practice of de-accessioning original art works whose representations were stored in image data bases. Some of the de-accessioned works decreased significantly in market value as a result. Many historians suspect that the private dealers who supported the New Luddites provided not only the finances but also a basic misconception of the nature of computer science that led to the Luddites' demand that all computers should be destroyed. When the National Gallery West Wing was burned down, a detective, who was also an amateur art historian, seeing the slogan "Remember LACMA", made the connection with the 1968 Edward Ruscha painting and was able to find the New Luddite member who started the blaze.

By consensus, one benefit from the New Luddite movement was a popular rediscovery of the masters of painting and sculpture. Those who objected to the extreme demands of the Luddites were forced to defend the fine arts as a means of protecting computer establishments, even if they had no prior interest in art. In the process many people from industry and academia developed appreciation for art.

7. IMPORTANT ADVANCES AFTER THE TURN OF THE CENTURY

The climate for major advances had been prepared by all the attention in the 90s when the Cognitive Science Institute began creating cognitive models of painters, working backwards from the present to the Renaissance. For many years formal computational models had been producing works in the style of many modern painters. What these models lacked, however, was a mechanism for making a choice among stylistically acceptable synthetic paintings. CSI's Computational Weltanschauung Model (CWM) used semantic networks to determine the choices that each painter would make. Thus among the 5000 synthetic compositions of Joan Miró that were generally considered stylistically acceptable, CWM selected two hundred, all of which corresponded to actual Miró paintings.

CWM was only the first of many cognitive models of the masters that were created. Much of the modeling was done by young art historians thoroughly trained in the use of descriptive computer languages who translated conventional literature into the new form suitable for incorporation into computational models.

In 2009, a major event firmly established the validity of computational art history. By this time CWM had been widely used to model the cognitive processes of painters through the end of the 20th century. But CWM had made a famous prediction of a painting that was basic to CWM's model of Miró. No such painting was thought to exist. But that year, a surprising discovery was made in, of all places, the U.S. State Department archives. At the beginning of World War 2.0, Miró had sent a series of 24 gouaches that he called the Constellations in a diplomatic pouch to Washington. Twenty three of these were widely known and of major importance in 20th century art. But a new Constellation was discovered in State archives after the passage of 69 years. And the famous discovery had been anticipated by CWM ten years previously. The predicted composition is shown in Figure 1. No explanation other than the validity of the CWM model was possible.

Thus began the period of rich advances in computational art history. Financial support was sufficient to allow for completion of the data structure classifying all known works back through prehistory. What had previously been viewed as a chronological taxonomy was now seen to be best described as a much more complex data structure. Each known work had a unique place based not only on time, authorship, school, provenance, etc., but also on structure, constructional history, spectrographic distribution, conceptual basis, literary influence, etc. There were 150 variables, some with as many as 1000 values that were used in this new taxonomy. All met the stringent requirement that the variable values could be computed from data within the data structure itself.

8. REACTION AFTER 2010

The major success of the decade at the beginning of the century spawned several developments that may be viewed as reactive in nature. The first was the vogue for Dada Undecideability. Since much new art as well as art historical and critical analysis was expressed in the form of algorithms, it was natural for attempts to be made to analyze these algorithms. Thus several dissertations were in the form of computer programs for comparing different algorithmic analyses of the works of individual painters. At the same time, computer scientists reminded the computational art historians that whatever results they had obtained in automated analysis of algorithms

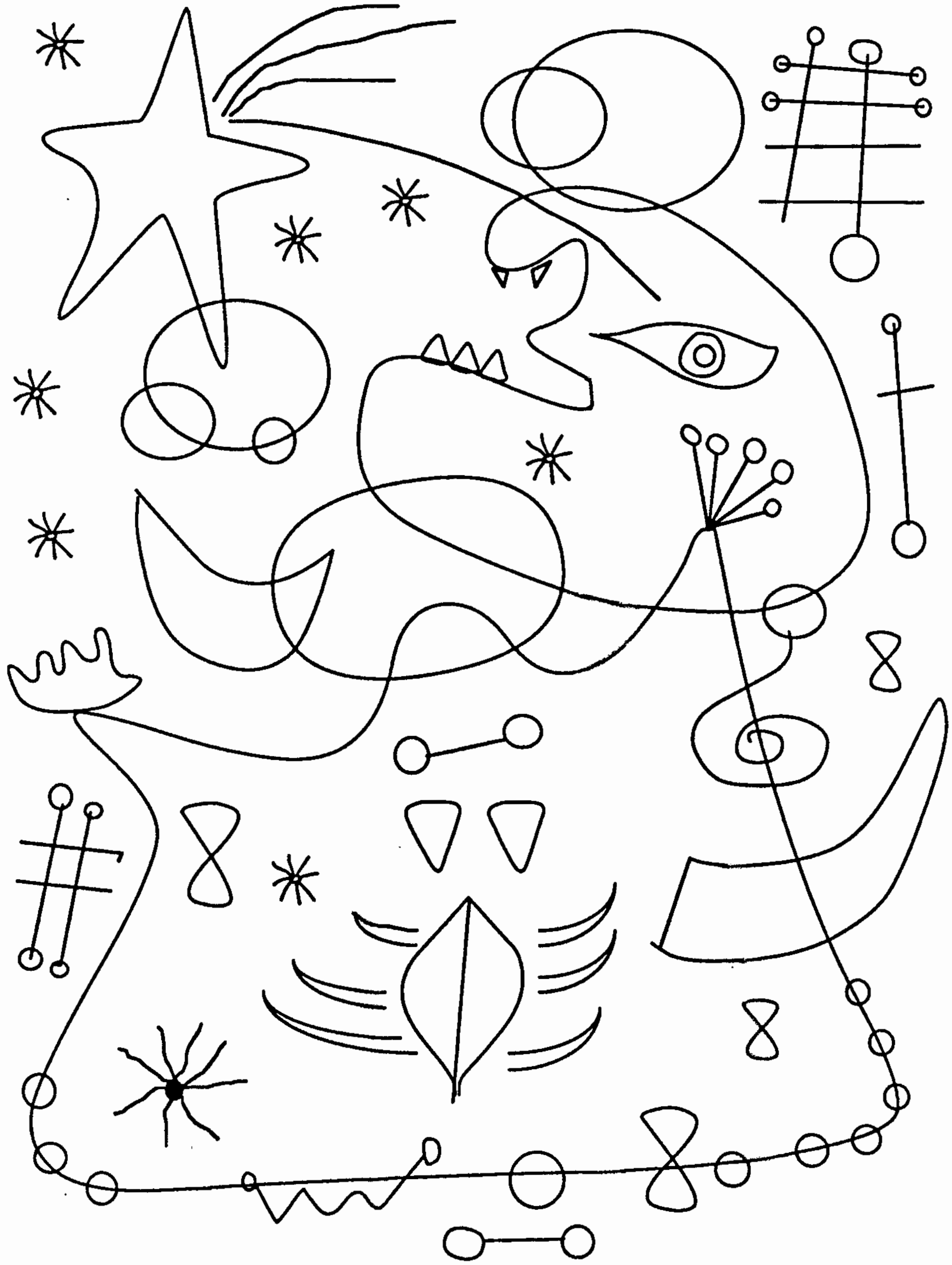

Figure 1. *The Miró composition predicted by the Computational Weltanschauung Model in 1999. It corresponds closely to the actual gouache painted by Miró in 1940 which is now in the collection of the Hirshhorn Museum of the Smithsonian Institution. (Courtesy of Russell A. Kirsch.)*

were fortuitous. They proved (by invoking classical computer science theory) that no general computational methods could exist for the analysis of art criticism algorithms. Some artists accepted these so called undecideability results as the basis for a new Dada Undecideability. They wrote algorithms for producing new works that resisted analysis. The new works were not very interesting but they did prove that all the common art criticism analyses gave spurious results when applied to the Dada Undecideable art. Only theoreticians remained interested for long, but the movement did give pause to the general acceptance of computational methods. Had the Dada Undecideability movement co-occurred with the New Luddite movement, each would have enhanced the other, but everyone had forgotten about the New Luddites in the intervening decade.

Despite the Dada Undecideability results, a strong movement developed for the exchange of computational art and its computational analysis. The automated art societies that formed around each network node explored many ideas that were now economical even though the ideas had been known, in some cases, for decades. One was evoked art and evoked analysis. This practice was based on the established fact that electroencephalographic (EEG) and electromyographic (EMG) signals produced both during the creation of an art work and during its viewing could be made to correspond with each other. So called "objective viewing" was achieved when the EEG and EMG of the artist and viewer were computationally equivalent. Some artists observed their own evoked EEG's and EMG's during their artistic activity in order to modify them to make objective viewing easier. Such works when viewed accrued many ICU's to the artists' accounts when successful objective viewing was achieved.

9. THE SITUATION TODAY

The situation today, in this writer's opinion, does not justify much of the enthusiasm that was widespread during the past four decades of computational art and art history. Of grave concern is the failure of massive support in the fine arts to lessen international conflict. Today, the arts rival defense in level of support. But no decrease in defense spending had resulted because the arts have contributed so greatly to economic productivity as to make support for both possible. That can be viewed as, at best, a partial success.

Another disappointment has been the extensive destruction of volatile art works. Many works have disappeared because precautions have not been taken to update them when the computer systems in which they were created were updated. Although this problem is now recognized, most works produced before 2010 are unrecoverable. Just as serious is the destruction of works in traditional media. For many of these, the existence of digital multidimensional counterparts was the incentive for ignoring conservation work to the point that the originals of some of these works have been irretrievably lost.

A source of some worry for public institutions is the practice of encryption. With the inflated prices that new art and all analytical work now command, both studio artists and scholars have begun encrypting their work and selling the decrypting keys. This has greatly reduced accessibility to all such work. The public networks suffer the most from this practice, but it was defended as an economic necessity by the Department of the Fine Arts in Congressional hearings.

Those of us who can remember the early days of computers and the fine arts perhaps can justify some nostalgia for simpler times. But those with a keen memory will also recall that our forebears were also suffering nostalgia for those simpler times when computers had not entered our lives at all.

NOTES

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8. This slogan is reputed to have originated with a chief curator at the old Museum of Modern Art.
9. Cynthia Goodman, *Digital Visions, Computers and Art*, (New York, Harry N. Abrams, Inc., 1987).
10. A good history of the technology used in space exploration appears in Appendix 1 of Kenneth R. Castleman, *Digital Image Processing*, (Englewood Cliffs, N.J., Prentice Hall, 1979).
11. David Marr, *Vision, A Computational Investigation into the Human Representation and Processing of Visual Information*. (San Francisco, W.H. Freeman and Co., 1982).
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13. E. H. Gombrich, *Art and Illusion*, (Princeton, NJ, Princeton Univ. Press, 1960).
14. The contemporary history of controversy regarding the adoption of the High Definition Television Standard was chronicled at the time in the *HDTV Newsletter* published by Advanced Television Publishing, Portland, OR, 97208-5247.
15. See "Senators Fight Erection on the Mall," *Washington Post*, June 20, 1997.